ENERGY MANAGEMENT IN ALLWATER: 5 YEARS ON – WATTS WORKED?

Jennifer Dreyfus, Allwater, Adelaide South Australia
Helen Beard, Allwater, Adelaide, South Australia
Nicolas Bockhoff, Suez, Paris, France
Andrew Jackson, SA Water, Adelaide, South Australia

ABSTRACT (500 WORDS MAXIMUM)

Allwater (a joint venture between Broadspectrum and Suez) operate and maintain the Adelaide Metropolitan Water and Wastewater Supply Systems through the Adelaide Services Alliance. Allwater serves approximately 1.3 million people where energy usage (approximately 93,000 MWh in 2017/18) and greenhouse gas emissions (approximately 69,000 Tonnes of CO_2 emissions in 2017/18) are significant.

The majority of Allwater's energy consumption is from key processes including:

- Treating raw source water to a drinking water standard;
- Pumping drinking water through the distribution supply network;
- Pumping wastewater (where required) through the sewer network; and
- Treating wastewater to a standard appropriate for discharge to receiving waters or for reuse.

In 2013 Allwater commenced the journey to develop an ISO 50001 certified Energy Management Program to better meet its sustainability responsibilities through reducing electricity consumption, maximising power generation (electricity from biogas), and in turn reducing greenhouse gas emissions. In addition, energy management was identified as a key area that can demonstrate both business and operational efficiency to the customer.

The first step in developing the Energy Management Program was to understand the power usage across the business to enable identification of opportunities for improvement. Training and awareness initiatives were developed and delivered which empowered personnel to manage energy effectively. Accompanying this was the development of a process for all staff within Allwater to submit energy efficiency ideas leading to many innovative solutions across all areas of the business.

Since the commencement of the program, large savings in energy have been achieved without compromising service to the customer. The process is ongoing and further work is being undertaken to provide smarter tools to dynamically manage our electricity usage and energy production in the context of electricity being purchased on the spot market by our Alliance partner, SA Water.

This paper outlines Allwater's Energy Management journey over the past five years and the lessons learnt, together with details of some of the innovative ideas implemented throughout the business which have led to significant energy savings.

KEYWORDS

Energy management, ISO 50001

PRESENTER PROFILE

Jennifer Dreyfus is an engineer with a broad range of experience in wastewater treatment from being a site engineer at Glenelg WWTP, plant supervisor at Bolivar WWTP and process optimisation engineer across all plants. Her focus has been to optimise plant operations to improve nutrient removal and onsite energy production.

1 INTRODUCTION

Allwater is responsible for the operation and maintenance of the water and wastewater systems in Adelaide's metropolitan region. This includes the provision of drinking water and recycled water and the removal and treatment of wastewater from residential and commercial properties across the metropolitan area. Allwater is responsible for operating and maintaining six wastewater treatment plants (WWTPs), six water treatment plants (WTPs), four recycled water systems, and over 300 water and wastewater pump stations.

South Australian Water Corporation (SA Water) (owner of the assets and Allwater's Alliance Partner) is one of the largest energy users in South Australia. Power usage has increased in recent years due to stricter environmental regulation, higher water quality standards and increasing water network pumping. In addition, new high-tech treatment processes (such as membrane bioreactors) are resulting in higher quality effluent, but are corresponding to increased energy consumption.

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2 ENERGY MANAGEMENT PLAN DEVELOPMENT

Allwater made a strategic decision in May 2013 to develop an Energy Management Plan, and adopted the ISO 50001:2011 Energy Management System (EnMS) framework to assist the planning process and to ensure on-going improvement. Figure 1 outlines the steps in the Framework.

An energy review was undertaken to capture and define the significant areas of energy usage within Allwater's operations. As part of this process, energy data from water and wastewater treatment plants together with major pumping stations was analysed. This analysis was used to identify parameters to enable Energy Performance Indicators (EnPIs) and baselines to be established. EnPIs are quantitative relationships between energy consumption and one or more relevant variables, such as the number of filters on-line to produce drinking water, or the number of pump run hours. Examples of the energy performance indicators are summarised in Table 1. This allowed Allwater to

understand and rank energy efficiency performance, highlighting operational areas to focus resources and implement efficiency programs.

Figure 1: ISO 50001 Framework

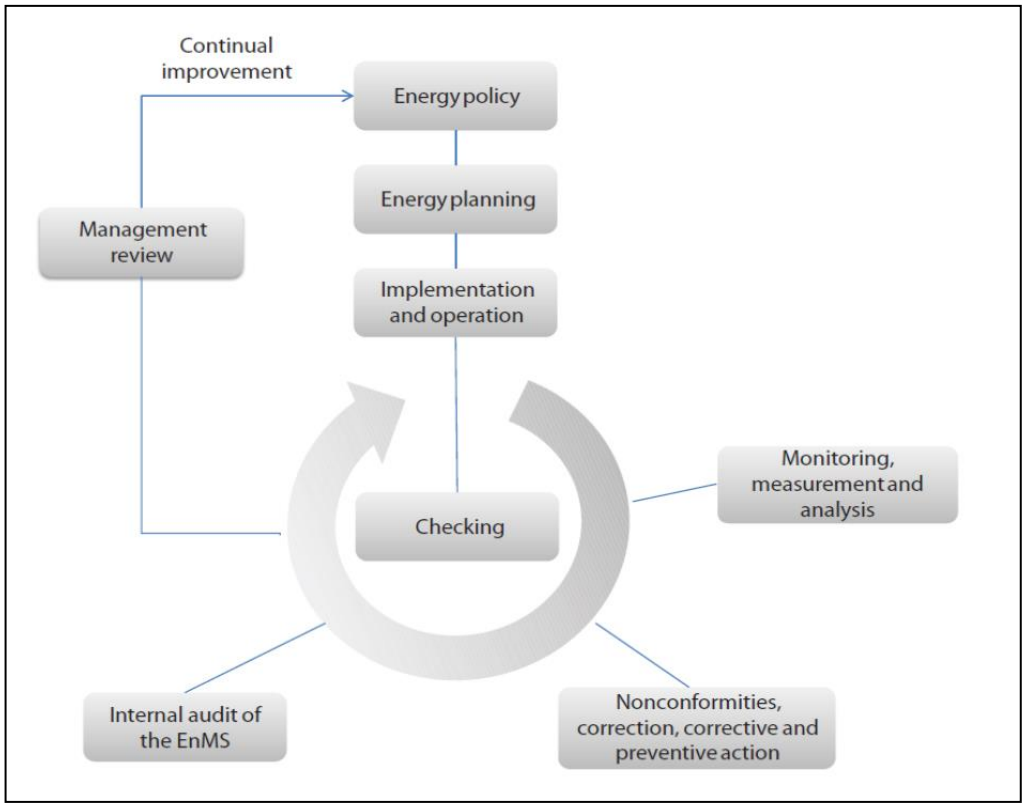


Table 1: Energy Performance Indicators

Area of Business	**Energy Performance Indicators**
Water and Wastewater Treatment Plants	kWh / ML treated kWh / pump run hours kWh / m^3 biogas produced
Water and Wastewater Pump Stations	kWh / ML pumped kWh / pump run hours
Fleet	L / km travelled (all fuels)
Head Office	kWh usage per month

Individual baselines were developed for the individual wastewater, water treatment plants and pump stations so that potential energy savings could be highlighted and to initiate investigations into improving efficiency. This also allows the verification and direct measurement of energy savings to be calculated to show continuous improvement and compliance with the ISO 50001 accreditation.

In summary, a total of approximately 120 days were spent incorporating the Energy Management Plan into Allwater's operations. The energy review and data collection were the areas that needed the greatest effort; followed by developing procedures and documentation. The procedures and documentation were then incorporated into daily operations through a communication plan, training and awareness.

After five years of maintaining the Energy Management Plan the energy review is still the largest and most important component of required time and resources to maintain the certification. However, the emphasis has shifted from developing the indicators and establishing baselines, to providing current and easily accessible energy performance information to Allwater personnel on a weekly and monthly basis.

3 ACHIEVING THE ENERGY PERFORMANCE TARGETS

Energy performance targets were set to drive improvements across Allwater. At the end of each financial year the energy performance for each site is reviewed relative to its baseline. In addition, every two years a new review is undertaken to identify the significant energy users for Allwater and also the main sources of power generation to assist with identifying further energy improvement opportunities. Allwater is now entering the third cycle of Energy Reviews, with the initial Energy Review undertaken in July 2014. Each review incorporates a baseline period of the previous 24 months of data to incorporate varying seasonal effects.

An Energy Action Team was formed with representatives from SA Water and Allwater, to review projects and progress. A summary of the performance against the targets over the last five years is provided below.

Target 1: Achieve and maintain ISO 50001 certification

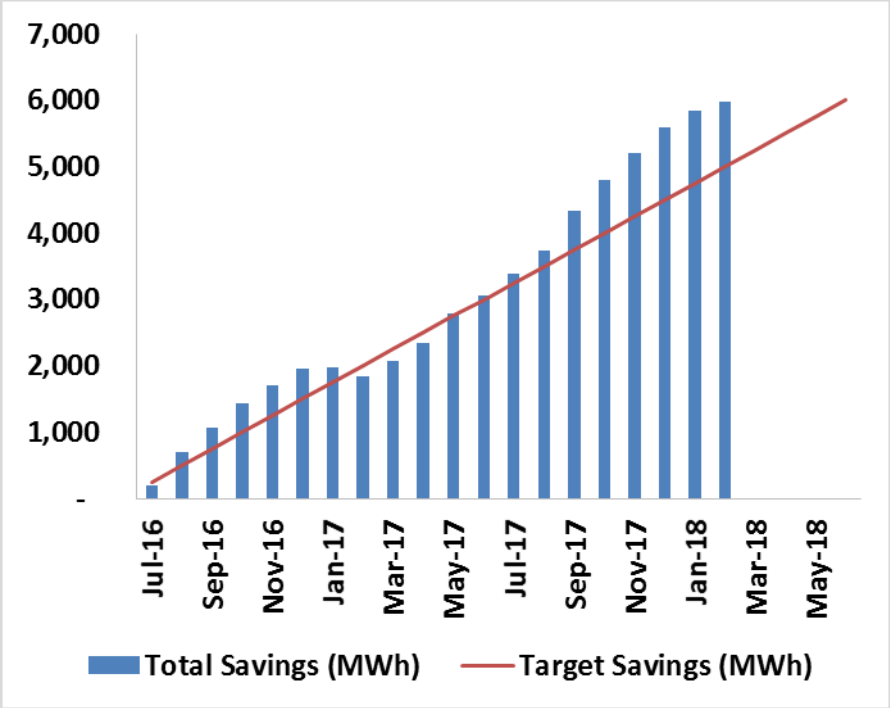
ISO 50001 Energy Management System certification was achieved in August 2014. Of significant note is that Allwater took the innovative step to become the first water utility within Australia (and to our knowledge within the Southern Hemisphere) to have their Energy Management Program certified against the ISO 50001 standard. This certification was maintained in August 2017.

Four internal and one external audits of the Energy Management Program have been undertaken in line with ISO 9001 and ISO 50001 requirements. All audits include a walk around the work-site to observe and make suggestions about possible energy savings. The audit program helps to maintain focus and enthusiasm for energy efficiency across the business.

Target 2: Reduce forecast electricity consumption across the whole company; initially the first review targeted 3%; the 2016 review a further 6% by July 2018. Together with maximising biogas power generation from the three main wastewater treatment plants

Allwater's initial energy profile showed that 89% of energy was sourced from electricity; leading to this becoming the initial main focus of energy efficiency projects. Through the implementation of many opportunities identified, Allwater has managed to achieve the targeted reduction in electricity consumption (Figure 2).

Figure 2: Summary of Energy Savings vs Target (note figure to be updated)



Allwater produces approximately 58% of its overall wastewater treatment electricity requirements through the anaerobic process at three Wastewater Treatment Plants (WWTPs): Bolivar, Glenelg and Christies Beach. The methane generated during the process is converted into electrical power and used on-site. Any biogas that is not used for power generation has to be flared on-site as at present none of the WWTP's have extra biogas storage capacity. Management of the biogas is important to produce as much as possible as well as reduce biogas wastage through flaring.

Biogas power generation has reduced Allwater's overall external electricity requirement by 20%. This fact highlighted the significance of any major plant failures affecting on-site power generation, resulting in the highest level of 'criticality' given to preventative maintenance programs. Table 2 shows the reduction in biogas flaring from 9% in 2014/15 down to 1% in 2017/18 at Bolivar since the Energy Management Plan was implemented.

Table 2: Biogas reduction at the Bolivar WWTP since the EMP was implemented

	Total Biogas Produced (NML)	Flared (NML)	Wasted (%)
2014/15	9,656	852	9%
2015/16	12,928	709	5%
2016/17	12,202	459	4%
2017/18	13,581	128	1%

Target 3: Implement five Better Way Energy Initiatives a Year

All staff within Allwater are able to submit energy efficiency ideas through our Better Way program. These projects ensure active involvement in energy saving ideas allowing energy efficient practices to be integrated into daily operations. This has led to a number of personnel-initiated innovative projects including:

- The installation of motion sensor operated lighting throughout six WTPs operated by Allwater.
- Creating an energy dashboard on the Allwater intranet to display energy usage, and to communicate information regarding energy saving operational tips and projects.
- Developing an energy savings calculator to aid procurement of power rated equipment for operations.
- Development of a water pump efficiency tool to monitor and highlight decreases in performance which may indicate the pump needs maintenance or replacement.

The target has been achieved for the previous five years with quite a spike in ideas submitted in 2014/15 (see Table 3).

Table 3: Number of Energy Related Submissions to the Better Way Program

Year	Number of Submissions
2013/2014	5
2014/2015	19
2015/2016	8
2016/2017	5
2017/2018	5

4 BIGGEST WINS

There have been a number of projects over the last five years which stand out and have provided the greatest amount of energy savings. These are summarized below.

Intermittent Mixing in Anoxic Zones

The goal of mixing in an anoxic zone is to keep the Mixed Liquor suspended and in contact with primary effluent and dissolved oxygen. As part of an energy efficiency review of several WWTPs, it was identified that the mixing of bioreactors was a priority area to improve. The mixing in the anoxic zones was operated 24/7, however, industry practice showed a trend towards allowing the operation of mixers in intermittent mode; with the set-points determined by operators at each individual WWTP.

In order to achieve this, each mixer was assigned an option in SCADA for the operator to define the on and off period during normal operation. In tanks where two or more mixers were installed, the control system was changed to allow for the mixers to operate alternately. During operational trials it was noted that on the whole intermittent mixing was successful and the optimum on / off operation varied between seasons and between WWTPs. However, it was discovered that any anoxic zones containing on-line analytical equipment required mixing 24/7 to ensure continuous accurate measurements were relayed back to SCADA.

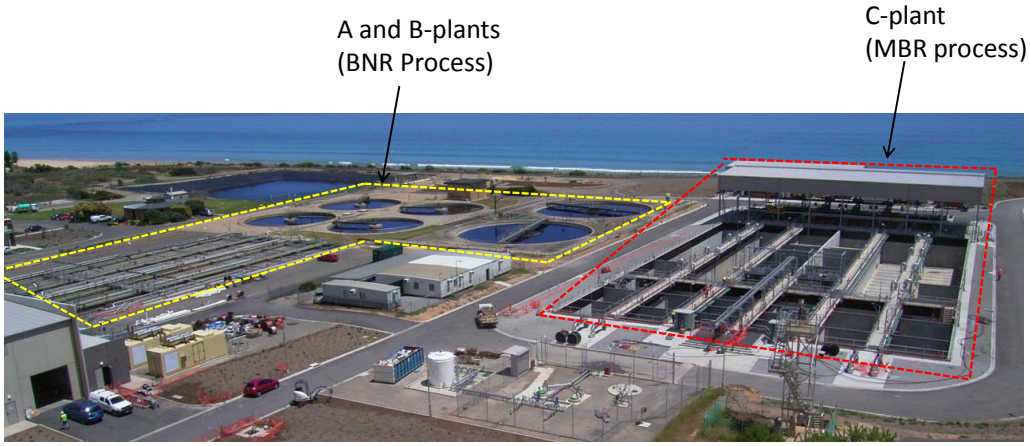
The intermittent mixing has been estimated to save at least 300 MWh/annum.

A solution to reduce energy consumption even further is the replacement of the existing mixers by equipment with motors utilising permanent-magnet technology. The measured energy savings between classic and permanent-magnet technologies is 10 to 15%. Allwater is progressively replacing mixers with permanent-magnet technology as an on-going maintenance program.

Christies Beach WWTP Flow Split Optimisation

The Christies Beach (CB) WWTP completed a major upgrade in 2012/13 with a 50% increase in plant capacity for projected growth and load in the catchment area over the next 25 years. The basis of CBWWTP design was to provide capacity to treat an annual average flow (AAF) of 45 ML/d. The existing A and B Plants take half of this flow (22.5 ML/d) with a new membrane bioreactor C-Plant constructed to take the balance (22.5 ML/d). The upgrade was also to ensure the required effluent discharge target of 100 Tonnes / year of Total Nitrogen was met. An overview of the site is shown in Figure 3.

Figure 3: Christies Beach WWTP showing A, B and C-Plants



The MBR plant is an energy intensive process due to the aeration requirements of the membrane filtration process and increased mixed liquor concentration within the bioreactors; however the process ensures high quality effluent for both suspended solids and nitrogen so our Environment Protection Authority discharge obligations can be achieved. The final completed plant saw electricity power usage double, however, sewage flow to the plant was only 70% of design. A detailed investigation was undertaken to develop an operating strategy that considered the ideal flow distribution through Plants A, B and C to achieve the target TN discharge load and minimise energy consumption at CBWWTP.

The resulting study showed that during the summer months, when effluent reuse was highest and discharge to sea was minimal, the design flow to A and B-plant was

maximised and one of C-plants bioreactors was taken offline. This strategy resulted in an effluent with higher nutrients but these were of benefit to the local irrigators who receive the treated effluent. During the winter months when effluent reuse was minimal, the reverse operation could be instigated with flows to C-plant maximised and either A or B-plant taken offline. This flexibility in operating strategy delivers an estimated energy saving of 700 MWh/annum.

Allwater is now undertaking a trial of Advanced Aeration Control at CBWWTP. This is a predictive aeration control based on ammonia load into the biological treatment stage, and feedback correction on actual treatment performance. Safeguards are in place to maintain Dissolved Oxygen within an acceptable range prior to effluent clarification so energy consumption can be reduced without compromising Nitrogen Removal. Indications to date suggest a further 15% saving in aeration power costs and savings in carbon dosing around 30%.

Bolivar SBR plant operating mode

The Bolivar High Salinity WWTP was struggling to consistently meet the effluent water quality targets which was thought to be due to the operational schedule and aeration set-points. An in-depth review was carried out to identify whether process related modifications could be made to improve effluent water quality. The resulting conclusions allowed operational staff to revise the plant's global operation in an attempt to improve the plant performance whilst reducing energy usage.

Influent flows and loads into the plant were studied over the course of 24 hour periods in order to refine the operating hours of each aeration profile: samples were taken at regular intervals and analysed for Ammonia and Nitrates. With the previous calibration of the plant's operation schedule, a given basin goes through each of its five treatment cycles with the same associated profile from one day to the next.

By tuning the operational schedule, the plant influent, together with the aeration control / dissolved oxygen set-point to specific times of day; the plant's performance became more stable which resulted in both improved nutrient removal and better effluent quality. Significant power savings were achieved due to aeration optimisation and decreased pressure on the blowers.

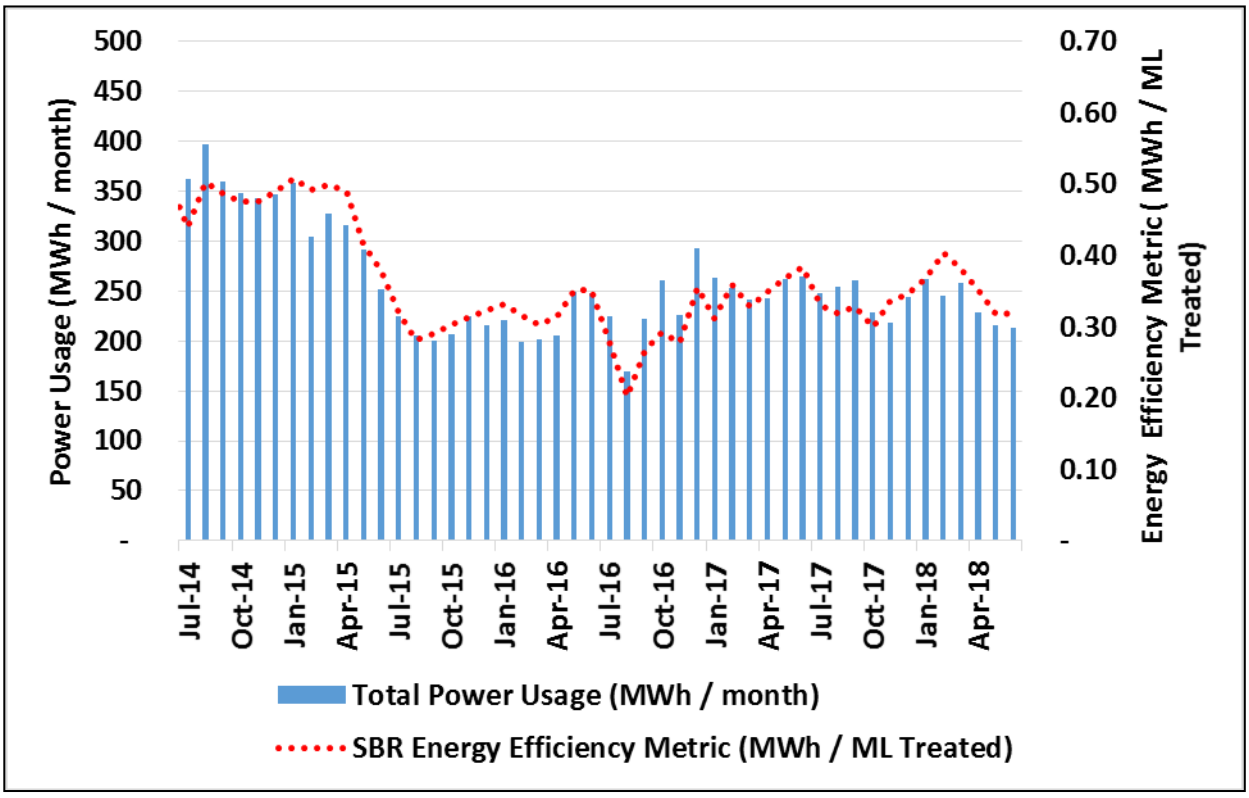
The monthly power usage and energy efficiency metric are depicted in Figure 4 showing on-going savings of approx. 100 MWh / month.

Increased maintenance and performance monitoring of diffusers and DO probes

The aeration process is the largest user of power across the business, so attention to this area can result in quick and easy savings in energy. By maintaining the dissolved oxygen probes with regular cleaning and calibrating ensures the correct dissolved oxygen set-points are being achieved.

Increases in head-loss through the aerators was experienced as a result of biological and/or inorganic materials build-up on the membrane surface. This build-up can increase aeration power usage and costs, so different cleaning procedures and maintenance schedule for diffusers cleaning was implemented. Regular diffuser back-pressure monitoring is being used as an indicator for cleaning to ensure the aeration diffusers are at their optimum.

Figure 4: Bolivar SBR plant Energy Efficiency Metric



5 CHALLENGES

Several challenges have been encountered over the past 5 years as Allwater have gone on the energy management journey. The main challenges have been the impact of Capital works and plant major maintenance activities which have delayed several planned energy saving projects, some indefinitely. An opportunity for further improvement has been identified in the encouragement of procurement and contractors to consider energy efficiency at the time of design and material selection.

Finding new energy efficiency ideas is becoming more and more challenging as expected. For the first two reviews savings were easier to find and projects quickly initiated, with a lot of the projects simply using a change in operational philosophy such as challenging the dissolved oxygen set-points for nitrification. There has been an opportunity identified to now focus on the other areas of the business for energy efficiency opportunities.

There is a significant amount of energy data to process and analyse. The management of this data is challenging and time consuming but essential to be able to monitor progress and identify opportunities. Ways in which to improve the efficiency of the data management is an opportunity for improvement.

Keeping up the momentum within the business and keeping the message 'fresh' is a challenge but also essential to keep staff engaged in the process. The Energy 'Better Way' ideas being submitted have plateaued, which can be a sign that energy efficiency savings are harder to find or employee enthusiasm is waning.

6 THE FUTURE

Allwater is working with SA Water to help achieve their 'Project Zero' goal of electricity zero net cost by 2020. SA Water are investing in renewable technologies such as solar-panels and Allwater are aiming to use even less power on site and drive towards self-sufficiency on two of the biggest WWTP's and reduced reliance on the electricity grid. Allwater is continuing to trial ways to optimise the aeration stage of wastewater treatment through initiatives from Suez such as of Advanced Aeration Control and AI:ien.

The third Energy Review has been completed and new targets established for 2018 to 2020. Targets and identified opportunities for improvement will be rolled out to sites and plans implemented to achieve these targets by 2020.

Training and communication will be on-going to ensure new employees are inducted and included in the Allwater Energy Culture.

7 CONCLUSIONS

Allwater has established an ISO 50001 Energy Management System to drive operational energy efficiency across its operations. This has resulted in greater access to energy usage information across Allwater and associated reporting systems have been developed to identify usage trends. From this improved understanding of energy usage, opportunities for energy efficiency have been identified and implemented. The initial targets established at the commencement of the journey have been achieved and many lessons have been learnt along the way. There are challenges for sustaining the Energy Management plan into the future including management of the data and maintaining staff involvement. Overall, the Energy Management system has been a success and Allwater, SA Water, and its customers will benefit from these energy reductions identified and implemented with potential for further savings in the coming years as more energy efficient projects and initiatives are completed.

ACKNOWLEDGEMENTS

Allwater would like to acknowledge all staff within Allwater for their contribution to the energy savings that have been achieved to date.

REFERENCES

ISO 50001:2011 Energy Management Systems – Requirements with guidance for use